AMSAT SATELLITE REPORT

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Towards Liquidity

For the last several years amateur satellite aficionados have been talking in terms of "kick motors". The average satellite user may well wonder why a kick motor is needed at all and, if indeed required, what it really does. This *ASR* Tech Brief* will highlight some aspects of AMSAT's anticipated use of kick motors and answer some of the questions you may have.

To reach a perch some 22,000 miles high, AMSAT's Phase IIIB "bird" will need all the energy that can be imparted to it by the Ariane launch vehicle. But the trip does not end there when the Ariane deposits Phase IIIB in the so-called "geosynchronous transfer ellipse", or simply the transfer ellipse. At that point it is necessary for AMSAT to place the bird in a new orbit that will satisfy the mission requirements it has set forth for the satellite. The transfer ellipse is not a particularly useful orbit. Moreover, there is a strong incentive to move to a new orbit promptly, say within a few weeks. This is because the perigee (low point of the orbit) is only 132 miles. If left alone, the satellite would soon "fall out of the sky" due to atmospheric drag-induced slowing; not a prospect to warm the hearts of the world's amateurs. So AMSAT must find a way to adjust the geometry of the orbit to one which will fulfill the dual objectives of: a) having long-term stability and b) providing maximum utility for most of the world's amateurs.

The Phase IIIA satellite was equipped with a solid fuel rocket which, had it had the opportunity, would have modified the transfer ellipse to the final orbit with a single burst lasting 20.5 seconds fired when the satellite was a bit past apogee. The kick motor resembled a metal sphere about the size of a bowling ball having a nozzle attached and weighing 86 pounds. If you took a similar kick motor and strapped it to the back of your VW, it would have provided an acceleration of about 0.2g. That would take your VW to about 87 mph in the 20.5 seconds of burn. That's not too much better than the VW could do on its own, but when bolted into the center of the Phase IIIA satellite, the acceleration is amazing. Since Phase IIIA weighed only

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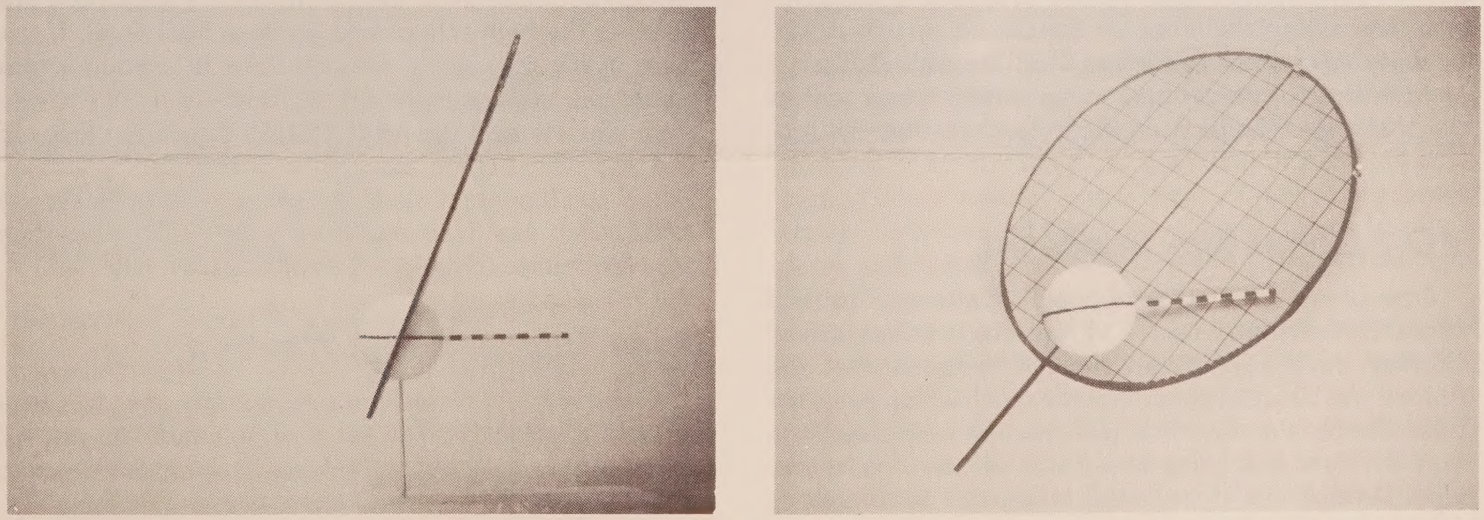
*ASR *Tech Briefs are an irregular feature to appear whenever significant developments in the technical domain warrant attention by the user community.*



A model of the earth and the Phase IIIB orbit is shown in the photos above. The scale has been adjusted slightly. On the left is seen the earth (white circle), with the equator marked (horizontal solid line). North is up. The striped marker lies in the plane of the equator. The long, dark oblique line is the orbital plane seen edge-on. The inclination of the orbit is the angle between the striped marker counterclockwise to the orbital plane (dark line). As configured here, that angle is about 60°. (The ascending node is on the near side of the model.) The photo on the right is of the same model from a different perspective. In fact the change has been 90°. Here the orbit can be seen to be an ellipse and the shape can be inferred from the grid. As can be seen, the grid presents not squares but diamond shapes since the top of the ellipse (apogee) is further away than the bottom (perigee) from the viewer. The satellite is assumed to move counterclockwise around the ellipse. The striped marker has now been moved to that point on the equator where the plane of the orbit intersects the plane of the equator (ascending node). A solid black marker is seen extending from the perigee point. Beginning at the striped marker and rotating counterclockwise to the solid marker yields an angle called "argument of perigee." Here it is shown to be about 225°. The geometry of the model approximates the Phase IIIB orbit after kick motor burn.

Survey of Amateur Radio

The lead article in the March *QST*, "Survey of Amateur Radio, 1980", is being hailed as one of the most significant articles to appear in the amateur media in years. The article by ARRL Assistant General Manager, K1ZZ, is a synopsis of a comprehensive survey performed under ARRL commission by The Institute for Social Research of the Florida State University. AMSAT Officials are particularly elated to note that their own in-house, oft less than rigorous surveys of amateur interests have been borne out by the ARRL survey. Specifically, when asked, "How interested are you in the following areas of Amateur Radio activity?", 56% cited amateur satellites as holding at least some interest for them. More significant than that raw statistic is, however, that *more* individuals cited "satellites" than any other of the remaining eight selection options (multiple selections were allowed). *ASR* will present its own view of the significance of these findings in a future issue. Meanwhile, manufacturers and distributors would do well to sit up and take note of what direction the amateur radio community has said it wishes to take for the future. Space Science, it would appear, has maintained its fascination for many amateurs. AMSAT plans to be there to support the influx expected after Phase IIIB is aloft.

Phase IIIB Tests

Tests of an important Phase IIIB transponder subsystem are reaching a climactic phase as we go to press. Word from DJ4ZC's lab at the University of Marburg was that the tests on the HELAPS (High Efficiency Linear Amplifier by Parametric Synthesis) were going well and all results were favorable. Based on the tests, a determination will be made to learn if the technique employed for the U-band transponder will provide the desired performance level for the proposed L-band version. The design challenge on the L-band version is particularly stern because the band will be wide (800 kHz) and the state of the art may not, at present, be equal to the challenge. The tests on the U-band version will provide key insight to scaling to 23 cm.

AO-7 Codestore Success!

Operations VP K1HTV reports that attempts to load codestore by control station VE3HCR have at last proved positive. Rich says that Dave (HCR) found that the upload was successful but that the clock which gates the data out for the downlink was running very slowly. In fact the data was being keyed out at only one or two wpm. At that rate it was very difficult to determine, at first, that the codestore mechanism was working. But given the clue that the clock was running slowly, the correct codestore downlink could be readily confirmed. K1HTV suggests that component aging in the astable multivibrator that clocks the data is likely the cause of the low transmission rate. On the other hand it is good news that the circuits are working at all since that may be a benchmark for comparison of the condition of other AO-7 circuits.

Launch Vehicle Swap

The European Space Agency (ESA) has begun a series of actions designed to minimize the impact of the continuing tests on the Ariane engines. ESA has given indications that some of the payloads in the early operational launches may be swapped with others that have critical launch windows. At press time it appeared likely that Phase IIIB would be swapped from its present berth on launch L7 to either L6 or L8. Also, it appears that the launch schedule will be stretched out so that L6 will be launched in the March/April 82 frame, L7 in May/June and L8 in June/July. In any case, however, AMSAT's ride seems quite secure despite some concern expressed as regards the flux in the schedule. Officials at AMSAT explained that at this stage of a program there is always a great deal of adjusting in schedules and payloads. "It is," as W3GEY expressed it, "just the way of doing business at this stage of development and shouldn't cause concern."

AO-8 Schedule

As predicted, AO-8 has begun to cool from the high of 47°C observed last month to the mid 30's at present. Accordingly AO-8 will no longer provide dual A/J mid-week as had been the case recently. The schedule published in *QST* will be followed though occasional deviations to dual A/J remain at the discretion of the AO-8 control station team members. The published schedule calls for: Mode A on UTC Thursday and Monday; J on Saturday and Sunday and A/J on Friday and Tuesday. Wednesday is experiments day.

OSCAR Education

The ARRL's OSCAR Education Manager, Mark Wilson, AA2Z, has undertaken to restimulate the Education program at the high school and grade school level. If you have in the past made presentations to schools and/or would like to do so in the future, Mark would like to hear from you. He says the ARRL OSCAR Education Program can and will provide assistance with materials and advice if you'll contact Mark. Call or write to Mark Wilson, AA2Z, Club and Training Department, ARRL, 225 Main St., Newington, CT 06111. Telephone (203) 666-1541.

Area Coordinators Needed

A revised list of needed area coordinators has been released by K1HTV. The list now includes: AL, AK, AZ, DE, KY, Eastern Mass., MD, NM, SC, and VE3, 4 and 6. Contact K1HTV for further info.

Satellite W.A.C. Per WØCA

An informative write-up on how WØCA pulled off his W.A.C. miracle appears on page 33 of March *QST*. A most intriguing map was constructed by W9KDR to support the explanation. From the map it would appear that many others could obtain W.A.C. if they worked at it and the activity levels of key areas/stations were up.

ON THE HORIZON

A Calendar Of Future Events

April 1981

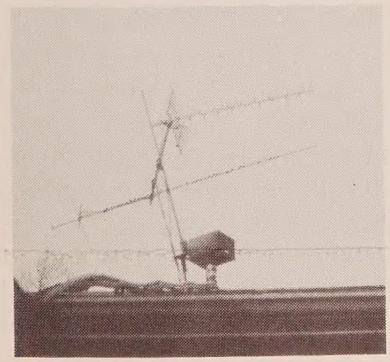
11: Project OSCAR Mtg., Palo Alto
11-12: Phase III Command Mtg., GSFC
15: UoSAT: T = − 5 Months
18-19: Board of Directors Mtg., GSFC
24: Phase IIIB: T = − 12 Months
25-26: Dayton Hamvention

Details:

A general meeting of Project OSCAR on April 11 has been announced by Project OSCAR President W6XN. The meeting is to be held from noon to 4 P.M. at Harry's Hofbrau at the Palo Alto golf course/airport. Reports on SYNCART progress and elections to the B.o.D. are on tap as well as two films on ESA's Ariane rocket and Kourou launch facility. Talk-in on 147.15 and 224.94. Contact W6XN (415) 941-6988 for further details.

New/Interesting DX

VE6AMB caught a big one a few weeks back: UAØARK. He was worked on Mode B cw. (Tks WØCY.) HI1RCD is back on B ssb with a good signal. (Tks WØCA.) And 9H1CE was worked by G3IOR on cw at 29.430 (Mode A). Pat says this is a new station from Malta. (Tks G3IOR.)



The OSCAR antennas that produced Satellite DXCC #1

Ben seated at the operating position of W2BXA.

AMSAT Spotlight On: W2BXA

Did it never strike you as odd that those who have the least about which to be modest are often the most humble about their accomplishments? This week's subject is a suitable example. Ben Stevenson, W2BXA, has done it all in general DXing as well as satellite DXing. Yet Ben is quick to down play the difficulty of the many awards he has earned. This is not the generally held perception of a first-rank DXer with 364 countries worked! Yet this is the nature of the individual, it would seem.

But DXing has not been the only interest Ben has had. For example, during the Viet Nam conflict he would run several dozen phone patches per day from South East Asia to servicemens' families in the U.S. under the MARS call AF2BXA. Later, as hostilities ceased, Ben sought to take up a new challenge and focused upon OSCAR 6 as a new enterprise. After a couple of years on AO-6 and 7 Ben became the first ever eligible for Satellite DXCC. His Satellite DXCC #1 proudly decorates his well-equipped shack in Northern New Jersey. Ben says his biggest thrill on the way to DXCC/S #1 was his snaring TU2EF. He had heard TU2EF for about ten minutes before predicted AOS because of good 10 meter propagation but could not access AO-7A. When finally a 10 second window opened, it was enough for the two cw experts to complete an exchange. The range for that QSO was right at the theoretical maximum. All told, Ben has 112 worked, 111 confirmed on OSCARs. But Ben is quick to point out that his accomplishment in garnering DXCC/S is largely a matter of geography. One award that eludes him is Satellite W.A.S. The RS satellite which was his chance to work Hawaii never was on long enough to allow the N.J. to Hawaii QSO.

When asked which of his many awards he values most, Ben quickly points out his W.A.Z. #1 in a prominent place on the wall. This award was earned in 1947 when Ben worked C8YR in zone 23. Moreover, the award was expedited by noneother than the famous Russian Arctic explorer Ernst Krenkel, callsign RAEM. (After whom is named the Krenkel Central Radio Club of the Soviet Union.) W2BXA and RAEM were good friends for many years and Krenkel helped Ben's W.A.Z. by getting some of the Russian QSLs expedited.

Ben was first licensed in '29 (as 2BXA) and built his first rig (as most did). It was an RCA 210 Hartley oscillator feeding a Zepp with open wire feeders. Today, however, Ben sits patiently waiting for the dawn of the Phase III era and looks forward to the new type of satellite environment it represents. Ben almost helped launch Phase III last year as team chief of the Pre-launch AMSAT Launch Information Net (ALINS) which brought the world's amateurs the latest news on the impending launch. His advice to would-be DXers? Set a goal and then persevere! Right, Ben! I think that's what the AMSAT team had in mind when putting the loss of Phase IIIA behind us and setting out afresh for Phase IIIB (and IIIC)! Good advice, and we'll take it. 73 es GL to a FB OM de AMSAT es *ASR*!

Towards Liquidity (Continued from page 1)

about 1/10 as much as your VW, when the kick motor was fired, it would have accelerated Phase IIIA at 2g to start with, building to an astounding 9g at burn-end. The acceleration builds because much of the spacecraft's mass is rocket fuel. The fuel is quickly expended reducing the overall mass and increasing acceleration. How much is 9g? A human subjected to 9g would survive only under special circumstances. Most high performance combat aircraft are rated up to about 7g; after that the wings fall off and other nuisances occur. So 9g is more than a slight jolt! The result of the 850 pound thrust on the velocity of the spacecraft is equally astounding. The Phase IIIA satellite's velocity would have *increased* by a whopping 2500 mph (1124 m/s). The effect on the orbit would have been to raise the perigee from 132 miles to an AMSAT-OSCAR 7-like 967 miles and to have simultaneously increased the inclination from 17° to about 56°. The eccentricity and an angle called argument of perigee would also have been changed by the kick motor firing. (See photo.) The apogee (high point) would have remained largely unaffected, however.

The whole plan was carefully balanced to obtain the maximum usefulness of the satellite given a finite amount of energy with which to maneuver the satellite to a new orbit from the transfer ellipse. Tradeoffs had to be made between the weight of the spacecraft and the more desirable orbital geometries. (Recall that the more the bird weighs, the less acceleration is possible.) Other tradeoffs had to be made too. For example, as is well known, when attempting to learn the characteristics of an unknown orbit, the longer the period over which measurements are made, the more accurate, in general, become the results. So on the one hand there is a desire to study the orbit longer to refine the accuracy, i.e. to better know the position and attitude of the satellite. On the other hand, as mentioned earlier, it is necessary to fire the kick motor early to avoid the risk of an early demise. Thus, Phase IIIA was a carefully contrived balancing act trading risks for potential benefits.

Until very recently it was assumed that Phase IIIB would be designed with similar tradeoffs. (With some additional complications.) Recent studies have indicated the desirability of improving the radiation shielding on Phase IIIB to prolong the IHU (computer) life in orbit. But at what cost would the extra weight of the shielding be aboard? Could weight be saved elsewhere? If so, where? If weight could not be saved elsewhere would the user community be happy with an orbit whose inclination of 50 or 52° (and the resulting rate of change of the argument of perigee) meant that the period of maximum usefulness would be 12 to 18 months rather than the 36 to 48 planned? Would they be discouraged by the prospect of changing locator system overlays at 30 day instead of 60 to 90 day intervals? Now, however, arises an interesting option for avoiding some of the difficult trades mandated. Enter the liquid option.

About two months ago a German firm suggested that under certain circumstances they might be induced to provide a liquid fuel kick motor for AMSAT's use on Phase IIIB. Let's for a moment contemplate what the liquid option could mean from perspective of the potential Phase IIIB user.

There are two fundamental advantages that liquid fuel rockets have over their solid fuel counterparts. First is restartability. Second is "efficiency". Whereas the solid fuel kick motor is a one-shot affair—push the button and away it goes; best hope it's pointed in the right direction—the liquid option gives substantial flexibility and reduces risk. For example, by using the liquid option one could perform a quick burn a few days into the transfer orbit to reduce drag by raising the perigee a bit. One wouldn't have to wait for the refinement of data that might take weeks. Then, when refined data *was* available, a longer burn could be done with the assurance that one knew both the position and attitude (pointing) of the satellite to the desired accuracy. The refinement of the orbit might continue as required until the exact niche was found, though precise station-keeping efforts are not anticipated as being necessary.

Furthermore, because of the higher efficiency of the liquid fuel, meaning you get more kick per pound of fuel, other favorable outcomes are possible. If more "kick" is available, how shall it be expended? First, more kick means we could attain the most desirable elliptical orbit inclination of 63° (called Molniya orbit). At this inclination the apogee would stay fixed over the northern hemisphere where most of the world's amateurs live. That means more coverage for more amateurs. Further, since the Molniya-type orbit does not shift, the nuisance of new tracking device overlays would vanish. Moreover, increased kick means more weight can be carried. And more weight can mean more radiation shielding which in turn means the satellite should live longer. Finally, more weight could also mean more equipment could be carried aboard. And more equipment could mean a second transponder which would strongly augment satellite utility.

In sum, the liquid option must be carefully evaluated. The liquid option is not without cost or risk. AMSAT would have to provide the fuel tanks and that would be an additonal cost not presently budgeted. And reliability data on liquid fuel kick motors is not as extensive as that for their solid fuel relatives. Yet in view of the potential advantages in improving overall mission effectiveness, the liquid option will require careful scrutiny which pays due homage to the risk/reward equation. Finally, though Phase IIIA never got the chance to demonstrate its merits, the interval between its completion and that of Phase IIIB has not been wasted. Progress is being made daily on a number of fronts. But the liquid option is certainly one of the more interesting options to appear.

Space Shuttle Activity

The Space Shuttle is scheduled for launch 10 April as of this writing. At least three N.A.S.A. facilities plan special events station activities to coincide with the launch. Below are those activities so far reported:

From Cape Canaveral, WB4ICJ on: 7280, 14285, 21380.

From Marshall Space Flight Center WA4NZD on: 3810, 3910, 7210, 14310, 14240, 21310, 28610.

From Goddard Space Flight Center, WA3NAN on: 3560, 3725, 3960, 7060, 7125, 7260, 14060, 14306, 21060, 21150, 21360, 28060, 28160, 28560, 29600 (FM), 50060, 50160.